PHM
PEGASUS

The Manual

Briefing Transcript

(The following address by Colonel Salisbury was delivered to the top graduating students from the Annapolis Naval Academy. The address followed an intelligence summary by Captain Pietro Salieri of the Italian Navy and an operations summary by Commander James Swinburn of the British Navy. Admiral Oliphant was in attendance.)

Good morning. I'm sure you all know each other by now, so introductions should not be necessary. My name is Vernon Salisbury, and I am the Commanding Officer of TAG (for "Terrorist Action Group"), the special NATO task force formed to combat international terrorism and piracy on the high seas. You have all been selected on the basis of your dedication, your commitment to world peace, and, of course, your naval skills. You are the cream of your graduating class; the best there is in the world today. We have high hopes for you, with your help we will combat the piracy and terrorism that has become epidemic on the high seas.

In our search for the ultimate weapon against naval terrorism, we have found that one vessel combines the elements of speed, maneuverability and firepower to provide a force that is almost impossible to resist by most terrorist vessels. I refer to the new *hydrofoil*, a hybrid vessel that has been described as part boat and part aircraft. You will be gaining first-hand experience with hydrofoils in the next few weeks, but a short introduction may be in order for those among you unfamiliar with the fundamental concepts.

Briefly, the hydrofoil is a vessel that "flies" over water rather than cutting through it. To achieve this, the hydrofoil uses lift devices similar to the airfoil wings of an aircraft, except that its foils use the lift buoyancy of water rather than that of air, with the result that when the hydrofoil reaches a certain speed, it rises out of the water and skims along on its foils. Thus "foilborne," the hydrofoil is relatively unaffected by water resistance and surface turbulence, allowing it to travel fast and economically even over choppy seas. This, together with its maneuverability and firepower, makes the hydrofoil the ideal patrol vessel for keeping the peace in "sensitive" areas around the world.

Three different hydrofoils have been made available to us: the *PHM Pegasus*, the Italian *Sparviero*, and the Israeli *Flagstaff II*. The *Hydrofoil Operation Manual* in your information packet in front of you contains all the information you need on these three vessels. Your information packet also includes detailed descriptions of the missions you will be undertaking, as well as identification cards to help you identify the enemy vessels you are likely to encounter in your assignments. Finally, your information packet includes the Command Summary Card, which summarizes all the important operating information. We recommend you keep this and the enemy identification cards handy during your missions. Things happen fast out there, and there isn't always time to consult your manual for information.

Table of Contents

Part I: Getting To Know Your Hydrofoil 2

Part II: Assignments 3
- Scores 3
- Ranks 3
- The Missions 4
  1. Battle Training 4
  2. Graduation Exercise 4
  3. Terrorist Attack 5
  4. A Better Part of Valor 5
  5. Search for Terrorists 6
  6. Supply Convoy 6
  7. Surveillance Mission 6
  8. JIHAD 7

Part III: Hydrofoil Operation 8
- Introduction 8
- The View From the Bridge 8
- Operations Map 9
- Weapons and Defenses 10
- Damage 11
- Operating Instructions 12

Part IV: Technical Data 15
- A. Design Development and Background 15
- B. The NATO TAG Hydrofoils 20

Part I: Getting To Know Your Hydrofoil

Preliminary Training: If this is your first experience controlling a hydrofoil, you may want to sit back and watch a demonstration. Here's how.

When you have your computer up and running (see your Command Summary Card for details), you will be presented with a selection of assignments. Each assignment is a mission taking you to various sensitive parts of the world. These are described in detail in Part II of this Handbook. To watch the demonstration select **Mission 0** from the list of nine. As you watch, take note of the two "view modes" (*Bridge* and *Operations Map*) and the features you can control from each. You may want to read Part III of this Manual as you watch the demonstration.

When you feel you are ready to undertake a real mission, press **Shift-Q** to quit the demonstration and then select another one. We suggest you start with one of the early missions before attempting the more advanced ones.

Part II: Assignments

Once you have received basic hydrofoil training, you will be in a position to undertake the following assignments as part of the TAG task force. Of these eight assignments, the first two are part of your advanced training, and provide you with simulated combat experience. We strongly recommend that you gain proficiency in the first two assignments before you proceed to the more advanced missions.

At the end of each assignment you will receive a score and a rank, based on your performance during the mission. Scores are calculated on the basis of five factors, as described below. Note that the actual values will vary from mission to mission, because of the different objectives of each one. For example, in the first assignment (*Battle Training*), speed and destruction are the most important factors, while survival is not. By contrast, in the fourth mission (*A Better Part of Valor*), survival is most important, while destruction of enemies is relatively unimportant.

SCORES

1. **Main Objective**. Full points are awarded if the mission is successfully completed; no points if the main objective was not accomplished.
   Range: 1000 - 5000 points.

2. **Enemies Destroyed**. Points are awarded for each enemy destroyed.
   Range: 50 - 500 points.

3. **Enemies Damaged**. Points are awarded for each enemy hit but not destroyed.
   Range: 25 - 250 points.

4. **Time Remaining**. Points for time remaining are awarded only when the mission is successfully completed before time runs out. Points are for each minute of time remaining.
   Range: 1 - 4 points/minute.

5. **Survival Bonus**. Survival points are awarded when the mission is successfully completed or when time runs out, assuming you haven't been blown out of the water by the enemy. Points are awarded for each of the twelve sections of the ship that are capable of sustaining damage (six for the hull and six for the systems). Full points are awarded for undamaged sections, half for slight damage (yellow on the damage display), and no points for heavy damage (red on the damage display).
   Range: 20 - 200

RANKS

Ranks are based on points earned, with different scales for each mission, depending on their relative difficulty. For example, because the training exercise is the easiest of all the missions, you can only advance to Lieutenant, no matter how high your score. More difficult missions, such as the *Search For Terrorists*, allow

you to achieve the rank of Captain, while the most difficult ones, such as the *Supply Convoy*, allow you to reach the top rank of Admiral. In any case, to achieve the top rank in an assignment you must accomplish the main objective.

The ranks, in ascending order, are as follows:

Deck Mopper
Ensign
Lieutenant
Commander
Captain
Commodore
Rear Admiral
Admiral

THE MISSIONS

1. Battle Training
Ten enemy ships will be introduced to your training area off Key West, one at a time. These vessels will range from simple patrol boats all the way to the powerful Nanuchka II missile corvettes. This exercise is designed to familiarise you with the THM and its weapon systems.

Objective: Sink all simulated enemy ships
Rank Attainable: Lieutenant
Enemy Vessels: Patrol Boat, OSA I, Nanuchka II
Strategy Tips: This is a good learning assignment. Use your gun on the patrol boats, and save your missiles for the bigger ships.

2. Graduation Exercise
In this exercise, all the enemy vessels you encountered in the first assignment will be coming at you at once, doing their best to blow you out of the water. Sinking all the enemy vessels as quickly as possible is more important than surviving undamaged.

Objective: Sink all simulated enemy ships
Rank Attainable: Lieutenant.
Enemy Vessels: Patrol Boat, OSA I, Nanuchka II.
Strategy Tips: Get moving right away, you're a sitting duck if you don't. Use your missiles on the more distant ships and your gun on the closer ones. Watch your radar for fast moving dots approaching your ship. These are enemy missiles. Use chaff to deflect them (see Part III of your Manual for instructions on using chaff).

3. Terrorist Attack

Approximately eight hours ago, terrorists attacked a seaside resort, killing dozens of vacationers and wounding hundreds. The terrorists were seen fleeing west in various patrol craft. Witnesses estimate seven to ten vessels of varying types, some suspected to be OSA I missile boats, others small patrol vessels. Your mission is to seek and intercept these vessels, and sink them.

Be advised that interventionist forces from nearby countries may attempt to aid the terrorists as they try to escape to their base. Be particularly alert for enemy ships heading southwest out of Syrian waters. The terrorist base is suspected to be somewhere on Cyprus, but the terrorists split off into at least four separate groups when fleeing. An Israeli *Flagstaff II* with Gabriel missiles has been made available.

***Objective*:** Sink all terrorist vessels.
***Rank Attainable*:** Commander.
***Enemy Vessels*:** Patrol Boats, OSA I, OSA II, Zhuk.
***Strategy Tips*:** The terrorist vessels are to the west of your starting position and moving rapidly north. Try to cut them off, while avoiding (or destroying) their allies coming in from the northeast. Save your missiles for the OSA class ships.

4. A Better Part of Valor

War is brewing in South America. Your PHM is needed there as soon as possible. From your base at Key West, you will need to navigate the dangerous Yucatan Straits between Mexico and Cuba in order to reach southern waters. To accomplish your objective in this assignment, you need only get the PHM to the southern edge of the map. Look out for enemy vessels who will be trying to stop you. Use your SeaSprite helicopter to screen your PHM and help you avoid the enemy, or to help you seek out and destroy them.

***Objective*:** Escape with your hydrofoil off the south edge of the map with as little damage as possible.
***Rank Attainable*:** Commander.
***Enemy Vessels*:** Komar and Assad missile boats.
***Strategy Tips*:** Keep moving at full speed. Engage enemies at extreme range with your missiles if they are in your path.

5. Search for Terrorists

Two missile corvettes have unsuccessfully attacked an American base off the southern coast of Sicily. A Sparviero hydrofoil (armed with Exocet missiles) and an AB 212 helicopter are available to help hunt them down. The mission objective is to sink both attackers (who will be fleeing south to a friendly port) before they escape. They are thought to be fleeing toward Tripoli, and can be distinguished from similar vessels by their course. Although a variety of enemy ships will be patrolling along a line north of Tripoli, remember that the fleeing ships are your main objective.

Objective: Sink the two fleeing Nanuchka II class ships
Rank Attainable: Captain
Enemy Vessels: OSA I OSA II Nanuchka II
Strategy Tips: Try to avoid the other ships on your way to your objective (the two ships fleeing south together). Save your missiles for them.

6. Supply Convoy

A South American country has been taken over by a dictator, who has succeeded in turning the Caribbean into a war zone. Your mission is to escort a special high speed cargo ship carrying medical supplies and food to a group of refugees. The dictator's forces consist of two varieties of a convertible Vosper-Thornycroft ship that comes with either two missiles and a small caliber gun, or just a 76mm cannon identical to your own.

Objective: Get your convoy ship to the southern part of the eastern edge of the map.
Rank Attainable: Admiral.
Enemy Vessels: Vosper-Thornycroft 121 ft class
Strategy Tips: Conserve fuel by keeping your engine setting at 2 or less as much as possible, sprinting ahead at high speed only when you spot enemies or when you fall behind your convoy ship. Keep the convoy moving at full speed toward the south one third of the east edge of the map, and use your helicopters to spot attackers before they can get close. Keep your hydrofoil between the attackers and your convoy ship.

7. Surveillance Mission

It is suspected that military equipment is being smuggled to the dictator through an outwardly neutral South American country. A cargo ship has been photographed loading up with tanks and aircraft parts in the Baltic, and is believed to be approaching Nicaragua. Seven ships of similar construction carrying farm machinery and building supplies are also entering the area to provide cover for the arms ship. Your mission is to find all eight ships and photograph them at close range so their identities can be established and compared with that of the suspected arms ship. Photography is accomplished automatically by approaching to within 1500 feet of the ship and training your binoculars on it (by choosing it as a target). ***Be careful not to sink them!*** Sinking one of these vessels will result in an international incident, and will immediately end the mission in failure. Use your two Seahawk helicopters to scout out the cargo ships. Some of the dictator's forces are believed to be in this area, so try to identify any ships you find at as long a range as possible. Watch your fuel usage!

Objective: Find and photograph all eight cargo vessels in the Carribean without sinking any.
Rank Attainable: Rear Admiral.
Enemy Vessels: Cargo ships, OSA II missile boats.
Strategy Tips: The cargo ships move slowly, but they are scattered all over the sea and will eventually reach safe port. Move fast, and use your helicopters to find them as soon as possible.

5. JIHAD

Your mission is to escort a supply ship out of the Persian Gulf. The only complication: a war is going on, and innocent ships are being fired upon without warning. The supply ship is trying to evacuate western workers from the war zone, but the captain is too frightened to try to escape through the maelstrom of warring factions that fill the Gulf. You will need to make your way through the Straits of Hormuz to Kuwait where you will rendezvous with the supply ship. The supply ship will respond to your controls in the same way as an auxiliary helicopter (see Part III of your Manual).

Try to avoid conflict if possible. Enemies are less likely to attack if you are peaceful. However, if you take hostile action or if you get too close, they will pass the word to their fleet to attack. The supply ship will be a tempting target for them at all times, so guard it well. In any case, remember that your primary mission is to get the supply ship out safely — damage to your hydrofoil is important only insofar as it compromises that mission. Use your two Seahawk helicopters to provide you with critical information on ship movements. Watch out for the ongoing battles — if you get too close you will be presumed hostile and fired upon. Watch your fuel and time limit!

Objective: Escort the supply ship safely into the Indian Ocean.
Rank Attainable: Admiral.
Enemy Vessels: OSA I and OSA II missile corvettes.
Strategy Tips: You're on your own for this one.

Part III: Hydrofoil Operation

INTRODUCTION

The hydrofoil is an all weather, high-speed, compact weapons system, making it ideal for strike, patrol and surveillance missions. Because of its fully submerged foils (see Part IV for technical details), the hydrofoil is capable of sustained high speed runs across heavy seas, with a maneuverability unmatched by any other sea going vessel. In addition, the hydrofoil carries an arsenal consisting of a 76mm gun, missiles (Gabriel, Exocet, or Harpoon, depending on configuration), and chaff for radar deflection.

As hydrofoil commander, you can switch between the view from the hydrofoil's bridge and a top-down view of the operations map. Each uses its own set of keyboard and joystick controls. Specific operating instructions are given in the Command Summary Card, included in your information packet.

THE VIEW FROM THE BRIDGE

Refer to Figure 1, below. The top half of the screen shows the view from the bridge. Inset at the top of the screen shows a close-up view through binoculars.

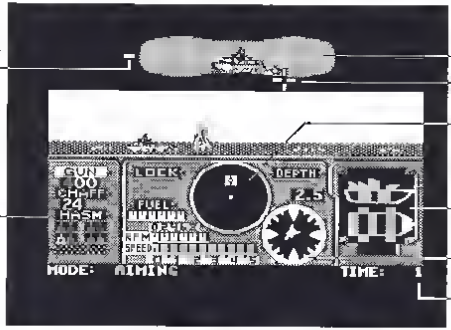


Figure 1: Bridge View

The lower half of the screen shows the hydrofoil's instruments. These are described as follows

Gyrocompass — Indicates hydrofoil's current bearing, north is straight up.
RPM — Indicates engine speed.
Speed — Indicates hydrofoil's speed in knots (nautical miles per hour)
Radar — Shows all craft within hydrofoil's radar range.
Weapons Status — Indicates which weapons are currently active and the number of rounds remaining
Fuel — Indicates the amount of fuel remaining
Warning Indicators — Red warning indicators show a potential problem:

Depth Indicates danger of running aground. Depth warning flashes to indicate that the hydrofoil is pointed toward land. An automatic avoidance system keeps the hydrofoil from running aground. Just turn the ship away from land to stop the warning.

Lock One or more enemy missiles are locked onto your hydrofoil. This means that the enemy have fired (or are about to fire) missiles at you

Damage — The damage indicators show which parts of the hydrofoil have sustained light or heavy damage. See detailed discussion below.

OPERATIONS MAP

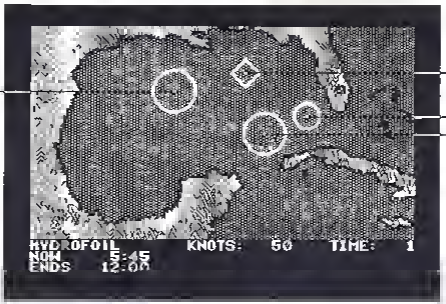


Figure 2: Operations Map

You can switch from the view from the bridge to a map of the surrounding area (see Figure 2). The map shows the entire area of operations for the current assignment. It shows all the major land masses, the borders of the assignment area, the current location of the hydrofoil, the locations of all the friendly forces and the locations of all enemy forces that are within radar range. The hydrofoil is shown in white, together with its radar range. In addition, the operations map shows the locations of your helicopters (if applicable, see below). Control of such helicopters or an escorted convoy is maintained from the Operations Map. See your Command Summary Card for details.

WEAPONS AND DEFENSES

Your hydrofoil is equipped with the very latest in offensive and tactical weaponry. The following information is a general description of each of the weapons and defense systems. Specific operating instructions can be found in the Command Summary Card.

76mm Cannon

The Oto Melara 76mm automatic water cooled cannon is widely used by navies throughout the world. Its fire rate of 90 rounds per minute makes it effective even against aircraft and missiles, while its range of almost ten miles makes it effective against small ships. Note, however, that because of the time needed for a shell to travel to its target, the Oto Melara's effective range against moving targets is approximately six miles. Thus, even though your fire control radar (see below) allows you to lock on to a target, you will need to "lead" your cannon ahead of moving targets further than one or two miles away. The further the moving target, and the faster it moves, the more you will need to lead your cannon, and the greater the likelihood of error. For best results, use the "aim corrector lights" around the binocular view to adjust your aim (see **Aiming and Firing Weapons**, below), and "walk the shells" in toward the target.

Chaff Rockets

The Mark 34 Chaffroc system on your hydrofoil allows you to fire exploding rockets filled with aluminum foil ("chaff") into the air. When they explode, the rockets disperse their chaff into the air, attracting the enemy missiles and deflecting them from your ship. Because the enemy missiles will tend to follow the chaff as your hydrofoil moves away, your best strategy is to fire the chaff when you are travelling at right angles to the oncoming missile. Timing is also important. If you fire too early, the missiles will lock back onto you when the chaff disperses. If you fire too late, the missiles will not have time to be deflected to the chaff before their proximity warheads explode. Chaff is best fired when the enemy missile is about a mile away.

Harpoon Missiles

The Harpoon missiles are your most accurate and most potent weapons. They will hit their target 90 per cent of the time and will destroy most small ships with a single hit. Because your radar is likely to be more accurate over greater distances than the enemy's, you can destroy an enemy vessel by firing a Harpoon at your maximum (40 mile) sighting range even before the enemy has a chance to launch against you.

Gabriel Missiles (Israeli hydrofoils only)
This missile has a shorter range than the Harpoon missiles (see above), but their guidance systems are reputed to be slightly more accurate than those of the Harpoons. In addition, they carry a 400 pound high explosive warhead. Use the Gabriels against ships beyond gun range.

Exocet Missiles (Italian hydrofoils only)
A French missile, used effectively by Argentina in the Falklands war. The Exocet is very similar in effect to the Harpoon missile.

Radar
Your radar system's range is generally 40 miles, although it is greater from the front or the back of the hydrofoil. You can take advantage of this by turning the hydrofoil towards the target. Your hydrofoil is represented by a flashing "blip" in the center of the display. If the blip is not flashing, another vessel must be very close to you.

Auxiliary Craft
Some assignments involve the use of search helicopters. In such cases, helicopters are controlled from the Operations Map (see above). The same applies to convoy ships, where applicable.

DAMAGE
Your hydrofoil is capable of operating even if it sustains damage. The following outlines the different kinds of damage and the effect each has on the hydrofoil's operation. Refer to Figure 3, below.

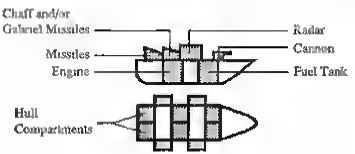


Figure 3: Damage Indicator

Hull Damage

The hydrofoil's hull is separated into six watertight compartments. Light damage (shown in yellow on the damage indicator, see Figure 3, above) to any or all of the six compartments does not affect the ship, but serves as a warning that continued hits will cause heavy damage. Heavy damage (shown in red on damage indicator) to a critical number of compartments can sink your hydrofoil. This critical number varies among the different hydrofoils, as follows: the *FHM* can sustain heavy damage to four compartments before sinking, the Israeli *Flagstaff II* will sink after heavy damage to three compartments, while the Italian *Sparviero*, the smallest of the three, will sink after heavy damage to two compartments. Note, however, that even with a critical number of compartments heavily damaged, a hydrofoil can still remain afloat while foilborne, but will sink only when hullborne. Note also that when foilborne, more of your hull is exposed, increasing the probability that enemy hits will damage it.

System Damage

76 mm Cannon: Light damage may cause your gun to misfire, heavy damage will disable it completely.

Radar: Light damage restricts your radar range to 20 miles; heavy damage restricts the range to 10 miles. Even though your radar may be heavily damaged, you still have a limited longer range view on your Operations Map, which simulates spotting by binoculars to compensate for the damaged radar.

Chaff: With light damage, the chaff rockets may misfire, expending a round in vain. With heavy damage, they will not work at all.

Missiles: With light damage, missiles may misfire; with heavy damage, they will not work at all. The same applies to the Gabriel missiles on the Flagstaff hydrofoils.

Fuel Tanks: Light damage increases fuel drain; heavy damage increases it even more. If you run out of fuel, your mission will end in failure. Keep to low speeds if you are running out of fuel.

Engines: Light damage decreases your maximum speed. Heavy damage decreases your maximum speed even more, sometimes to the point of rendering you completely immobile. Note that with light damage you may still have enough power to remain foilborne, but if you come down off your foils you may not have enough power to get back up. This could result in difficult tactical decisions in circumstances where you need to choose between staying foilborne and maintaining a higher speed, and coming down off the foils to slow down and conserve fuel.

OPERATING INSTRUCTIONS

You can operate your hydrofoil either from the Bridge or from the Operations Map. To switch from one to the other, press V on the keyboard. From the Bridge you can maneuver the hydrofoil, or select, aim and fire your weapons. You can also adjust your radar scanning range from 2.5 miles to 40 miles. From the Operations Map you can control your auxiliary vessels (helicopters or a convoy of ships, where applicable), or you can set your hydrofoil on a course using automatic pilot. Some operations are available in either mode. Thus, from either the Bridge or the Operations Map you can pause and restart proceedings, you can quit and select a new mission, and you can speed up or slow down the passage of time. (You can speed time up to 128 times, when you do so, every element is affected equally.)

These are discussed in greater detail below. Specific commands are given in the Command Summary Card

Bridge

Maneuvering the Hydrofoil You can maneuver your hydrofoil with either the keyboard or joystick Moving the joystick forward speeds up the hydrofoil while moving it back slows it down Moving the joystick right or left moves the hydrofoil right or left. See your Command Summary Card for keyboard equivalents Note that maneuvering the hydrofoil manually from the Bridge has the effect of disengaging the automatic pilot (see discussion under Operations Map, below)

Aiming and Firing Weapons You can also use the joystick to aim and fire your weapons Pressing the **Spacebar** toggles the joystick between *maneuvering* the hydrofoil and *aiming* your weapons. To aim at a target, you first need to select it from among the enemy craft within your radar range by pressing **T** several times until the target is bracketed on your radar screen At that point the targeted vessel appears in the binocular view at the top of the screen. To aim your gun, move the aiming cursor (see Figure 1) so that it is over the target in the binocular view Move the joystick forward to move the cursor up, and move it back to move the cursor down Moving the joystick left or right moves the cursor left or right. To fire a weapon, press the joystick fire button or **Return** on the keyboard You can correct your aim by using the "aim corrector" (see Figure 1, above): move the aiming cursor toward the aim corrector and fire again Note that you only need to aim your gun. Missiles automatically go toward the ship in the binocular view at the time of firing, while chaff affects all incoming missiles depending on their distance from the hydrofoil You can select among the available weapons from the keyboard See your Command Summary Card for details

Operations Map

Automatic Pilot. To set a course for your hydrofoil, first make sure that the hydrofoil is selected (by pressing the appropriate key, see your Command Summary Card). Move the crosshair to your destination point and press key 1 through **5** Pressing **5** moves the hydrofoil to its destination at full speed, while **1** moves the hydrofoil at its slowest speed If you already have a speed selected you can press the joystick button to move the hydrofoil to the new destination at the currently selected speed Pressing **0** stops the hydrofoil When you return to the Bridge, changing direction (with keyboard or joystick) disengages the automatic pilot and returns you to manual control You can, however, change the hydrofoil's speed from the Bridge (by pressing keys 1 through 5) without disengaging the automatic pilot.

To re engage automatic pilot, return to the Operations Map, select the hydrofoil then press the joystick button or select a speed as before. Your hydrofoil will then move toward the previously selected destination Messages on the Bridge and Operations Map indicate current status of the automatic pilot.

Controlling Auxiliary Craft When you are in the Operations Map you can also control the auxiliary craft that are available to you. Depending on the assignment, these can include helicopters, or a convoy of ships. To control an auxiliary craft, first select it by pressing the key for that craft (see your Command Summary Card for details) and then move the crosshair to the destination point. Press a key 1 through 5 to set the auxiliary craft's speed and start it off towards its destination.

Auxiliary craft in the Operations Map are color-coded: Helicopters are green, and the convoys are gray. Each auxiliary craft is also identifiable by its own icon. To display the auxiliary craft icons, press **D**. This changes the display from radar circles (circles around each craft showing its radar range) to the vessel icons. This feature is particularly useful if many enemies are nearby.

Time Compression You can use time compression to speed up events in the Operations Map until you get to the center of the action. You can then slow events back down, or you can leave them speeded up. If you like, you can play through the entire mission with time compressed up to 128 times normal. If you compress time to more than eight times normal, any action from the enemy (such as a missile or cannon shot) will automatically slow it back down to eight times. This way you can use time compression to make your assignments more challenging.

Part IV: Technical Data

(Prepared by Colonel Vernon Salisbury, Pegasus Hydrofoil Testcraft Master Ret.)

A. Design Development and Background

Early Developments

During the second half of the 19th Century, Thomas Moy, an aeronautical engineer, reasoned that by testing wing sections in water instead of air he could observe and measure the forces acting upon them more accurately. In 1861, after attaching three sets of wings (or foils) to his experimental craft's hull, he observed that it took only moderate speeds to lift his craft out of the water.

Over the next 70 years several inventors presented widely varying ideas in this area, although most were applied to seaplanes and not to marine surface craft. The first craft which could accurately be termed a hydrofoil was an experimental vessel built by Professor Enrico Forlanini of Italy. Forlanini was an eminent airship designer who turned to marine aircraft and boat building in the early 1900's. He discovered that a foil's lifting capability in water increased with the square of the foil's forward speed. Thus, a foil moving at twice its initial speed would produce four times as much lift. From this Forlanini deduced his "foil ladder" arrangement. He realized that by placing foils in a ladder like arrangement he could raise the hull high off the water, eliminating hull resistance almost entirely. This system gave a ship not only constant lift but also gave it virtually constant drag over a wide speed range. In 1906 his craft, driven by aircraft propeller, achieved a speed of 44 mph, demonstrating the feasibility of his system.

Other Contributions

Crollo and Ricaldoni. In 1907 General A. Crollo and O. Ricaldoni tested a remarkably advanced vehicle, similar in design to Forlanini's. It was driven by airplane propellers (with variable pitch at that) and was lifted by three sets of foils, with the front foil in the form of a wide "V". This was the predecessor of today's surface piercing foil designs. The V shaped front foil reduced drag and provided more stability than Forlanini's machine. It reached a speed of 50 mph.

Alexander Graham Bell. These early craft were obviously faster and had greater potential than displacement vessels of their day, but no more development for military or commercial use was to be conducted for the next 30 years. Not even Alexander Graham Bell's HD-4 was able to achieve much more than a speed record of 70.86 MPH. Back then, people simply had no need to travel across the water at more than 40 mph.

In the next 20 years hydrofoil development was all but forgotten, with the exception of a German, Professor Thetjens, who carried out exhaustive studies of foil reactions in waves. Another engineer, U. Grunberg of France, studied the related problem of sensing oncoming waves and designing a foil system which could make appropiate changes in lift to compensate for wave size.

Von Schertel Supermar. Most of today's commercial hydrofoils are based on a simple design by Baron Hans Von Schertel. He launched his first test craft in 1928. Six years and six hydrofoils later his commercially practical design caught the eye of Koln-Dusseldorf Steamship Company. They placed their first order for a surface piercing hydrofoil in 1937 with Gebruder Sachsenberg AG at Dassau, Germany. From this first commercial order evolved the Schertal Sachsenberg combine which was reborn in Switzerland after World War Two. Supermar AG licensed nine out of ten hydrofoil vessels built outside the Soviet Union. During the war German hydrofoil patrol craft were built by Hitler and then taken over by the Soviets. There are an estimated 1000 hydrofoils in the Soviet Union today.

Later Developments

The United States Navy became actively interested in hydrofoil development in 1957. A small contract was given to Gibbs & Cox to convert a small Cris Craft into a fully submerged foil system hydrofoil vessel from a design by the Massechusetts Institute of Technology. Technical progress in computers and sensors for aircraft automatic control and the research previously mentioned were combined to build and successfully operate this experimental craft.

This research craft was named *Sea Legs* and successfully flew from Boston to Annapolis in one jump in the open sea along the Atlantic seaboard. This seemingly effortless voyage inspired the Navy to become serious about the military potential of the new type of hydrofoil ship.

Sea Legs' design was a canard configuration with one foil forward on the centerline and with two foils aft attached to the outboard sides of the transom. The rudder was attached to the aft edge of the forward strut. Propulsion was a standard marine gasoline engine mounted forward in the main salon of the cabin, connected to a very long propeller shaft so as to achieve the lowest angle of attack for the propeller when foilborne. The autopilot was a bread board electronic analog computer connected to a set of ultrasonic height sensors mounted over the bow. A sensitive gyroscope and accelerometers connected in turn to servo controlled hydraulic actuators which adjusted the angles of the foil surfaces.

The height sensors measured the height of the waves just ahead of the forward foil and instructed the autopilot to make corresponding changes to compensate for the waves subsurface orbital turbulence. The accelerometers and gyro compensated for other outside disturbances and simply kept the ship on an even keel, or in this case well balanced upright on its foils.

Sea Legs contributed to hydrofoil development in two very important respects: (1) proving the fully submerged foil concept (2) the determination of the United States Navy to pursue the development of fully submerged foil systems for patrol and combat service to keep a jump ahead of Soviet surface piercing hydrofoil ships. Incidentally, while the Navy was funding *Sea Legs*, The Boeing Company built and tested *Little Squirt*, the first water jet propelled fully submerged hydrofoil research craft, thereby perfecting their own system.

With the data and knowledge gained from *Sea Legs* and Boeing's *Little Squirt* the United States Navy started to build the first operational hydrofoil ship. In 1960 the Navy announced a contract with Boeing to finish detail design and to produce and test the Bureau of Ships preliminary design of PCH-1 Patrol Craft Hydrofoil One, a prototype. It was envisioned and designed as a patrol hydrofoil whose major mission would be interdiction of high speed enemy nuclear submarines.

PCH 1 Highpoint became a research and development hydrofoil operated by the Hydrofoil Special Trials Unit out of The Naval Shipyard, Bremerton, Washington. Her sea-going ability was remarkable in the open ocean off the Oregon and Washington coastlines, and she once crossed the bar at the entrance to the Columbia River while foilborne, in sea conditions running over 30 feet. Destroyers and other vessels crossing this bar under similar conditions had taken hours to complete the transit, but *Highpoint* safely completed the bar crossing in a matter of minutes.

AGEH-1 Plainview is the largest hydrofoil in the world, according to the Guinness Book of Records. It was built as a research hydrofoil and made notable contributions in electronics and data gathering before being placed on the inactive list.

PGH 1 Flagstaff and *PGH-2 Tucumcari*. These Patrol Gunboats were designed and built by Grumman and Boeing to the same specifications. *PGH 1 Flagstaff* was built as a conventional hydrofoil system (two foils forward and one aft) similar to a conventional airplane. Propulsion was through a super cavitating prop with its gears and shafts in the aft strut. *PGH 2 Tucumcari* was a canard configuration with water jet propulsion. Both hydrofoils met or exceeded the specifications and were deployed to Viet Nam with excellent war records. *PGH-1 Flagstaff* was placed on the inactive list after testing by the United States Coast Guard. *PGH* 2 was grounded on a reef in the Caribbean and was stricken from the active list.

Both vessels were the inspiration for further developments. The *Flagstaff II* designed and built for the Israelis is a bigger and more capable design based upon the experience gained on the *PGH-1*. It featured better navigation, guns, and missiles.

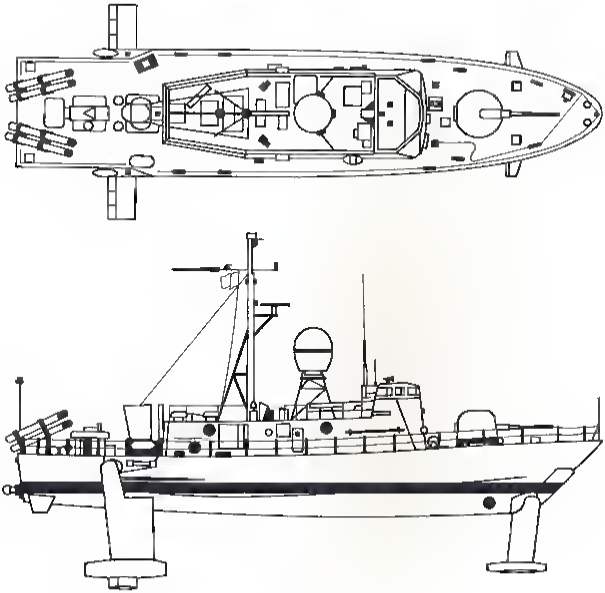
PHM-1 Pegasus

The *PHM 1 Pegasus* series Hydrofoil Ships were ordered, cancelled, and then reordered by Congress. Based on the design and experience of the *PGH-2 Tucumcari*, and upon the experience gained from both peacetime and wartime fleet exercises, they feature better systems, equipment, living quarters, and more effective guns and missiles.

The Pegasus class hydrofoil is an all weather vessel capable of performing a surface warfare role. The space and weight margins allow the addition of weapons or sensors for anti-submarine and anti-air warfare. The ship can be deployed anywhere in the world, replenished by the fleet or by a commercial tanker with appropriate fuel, and logistically supported. Functioning in a fleet task group, PHM hydrofoils provide high search effectiveness, concentration of attack firepower, and versatility in the choice and location of the attack platform. It is a significant threat to an enemy task group, hit and run terrorists boats, drug smuggling, gun running, or any larger more expensive naval vessel attempting to operate independently.

PHM Tactical Concept. The hydrofoil ship is an ideal low value barrier to deploy between high value vessels during tense pre-war tactical maneuvering, before the war opens into full scale hostilities. It can perform a "tattle tale" function by keeping enemy ships under close surveillance. The fire power of its missiles is equivalent to a battleship or cruiser and its speed permits a quick counterstrike reaction. If enemy missiles are detected in the air, PHM can deflect them with chaff away from itself or other higher value fleet assets. On board communications permit coordination of attack or defense with other fleet assets, such as ships, aircraft, or submarines. Space aboard is limited but sufficent to transport and land small counter insurgency units, such as seal teams, frog men, etc. PHM hydrofoils can routinely replenish at sea from auxiliary replenishment vessels, FFG frigates or LSD Landing Ships. The Mobile Logistic Group supports these hydrofoils from mobile type containers both aboard ship or ashore. Their homeport is Key West Florida, where they keep watch in the Straits of Florida, Straits of Yucatan, Carribbean Sea, and the Gulf of Mexico.

For more information see Part B, The NATO TAG Hydrofoils, below



PHM Pegasus

B. The NATO TAG Hydrofoils

NATO has three types of hydrofoils in its TAG task force: the *PHM Pegasus*, the Israeli *Flagstaff II*, and the Italian *Sparviero*. The following technical reference guide provides information in addition to the Operating Guide above.

Introduction

The NATO Hydrofoil is an all-weather, high-speed, sea-going weapons platform. It is designed to operate offensively against hostile surface combatants and other surface craft, and to conduct surveillance, screening, and special operations.

Propulsion

The NATO Hydrofoil uses both hullborne and foilborne propulsion. These can be used together or separately as required.

Hullborne: Two Motoren und Turbinen-Union (MTU) 8V331TC81 Mercedes Diesel engines drive two Aerojet Liquid Rocket Company waterjets with steering nozzles and reversers.

Foilborne: A single General Electric LM2500 Gas Turbine drives an Aerojet waterjet propulsion system. *Sparviero* utilizes a GE LM 1500 Gas Turbine. The *Flagstaff II* Gas Turbine drives a super cavitating propeller through gear boxes at the top and bottom of the single aft foil and strut system.

The Aerojet waterjet propulsors are axial flow units developing thrust in the nozzles from the flow of sea water. The intakes for the hullborne units are in the hull. The intakes for the foilborne unit are in the front of each pod at the junction of each foil and its strut on the aft two foils. When the foils are retracted the intakes are at the hull where the strut mates with the hull. *Sparviero* utilizes a single waterjet propulsor.

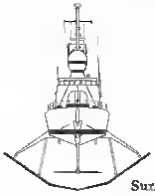
The air intakes are on the side of the deckhouse with demisters to entrap salt and sea water, thereby preventing damage to the turbine or diesel engines. The exhausts for both the diesel and the turbine generators are through the small stack unit aft of the deckhouse.

Power

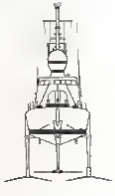
Electrical as well as hydraulic power is generated by two turbine generators. Hydraulic power is developed on the auxiliary power units by two Vickers hydraulic pumps. Hydraulic actuators apply the power to control the nozzles, reversers, strut retraction, bow thruster, and foilborne controls. Pressurized reservoirs supply the hydraulic fluid required.

Hydrofoils

Hydrofoils are underwater wings designed to "fly" in the water, in the same way as airplane wings fly in air. Because water is much more dense than air, small hydrofoils can lift PHM size ships. Hydrofoils come in two varieties — Surface Piercing and Fully Submerged (see Figure 4). Surface Piercing hydrofoils use a large V shaped foil at the front and a smaller one aft. Fully Submerged hydrofoils use foils that extend six to eight feet below the surface. Each type has its advantages. The Surface Piercing hydrofoils are more susceptible to surface turbulence, but are more stable when executing high speed turns. The Fully Submerged type, on the other hand, can provide a smooth ride even in heavy seas (up to 15 feet or more), but are less stable at high speed turns. Boeing's Automatic Control System (ACS), which make corrections through trailing edge control surfaces (similar to the ailerons on an aircraft wing), has virtually eliminated any turning instability. The Fully Submerged type is the one that is used by the U.S. Navy on the *PHM Pegasus* as well as by the *Sparviero* and *Flagstaff II* hydrofoils, while the Russian hydrofoils are predominantly Surface Piercing. Either kind provides quick response and a maneuvering capability exceeding that of most modern jet airplanes.



Surface Piercing



Fully Submerged

Figure 4.

Canard configuration of the hydrofoils (one forward and two aft) improves the rough water capability of the PHM by allowing the aft flaps to control roll even if the forward foil loses lift. Sparviero also utilizes a canard configuration. Flagstaff II uses a conventional hydrofoil arrangement of two hydrofoils paired forward and one aft at the transom. This puts the foilborne propulsion propeller on the centerline in the water where the propeller wake cannot interfere with the flow of the water over the foils.

Foilborne operation is smooth and easy to perform. After setting the depth, simply advance the throttle. The ship accelerates, lifts automatically to the ordered foil depth, and increases to the cruise speed. The throttle setting controls the cruise speed.

Hydrodynamics of the hydrofoils is designed to keep the ship operating within its speed and maneuver capability, called its operating envelope. Water flow over the hydrofoils must be kept smooth and clean, as is the case with airplane wings.

Navigation

NATO Hydrofoil ships use standard navigation procedures. Foilborne navigation at high speed is safer and more accurately conducted if the track is plotted beforehand. Autopilot control is a function of the gyro compass and the control system. Steering is standard as for all ships at sea but the planned track is usually done well in advance of getting underway. Keeping on track even at high speed is then much easier.

Rapid radar plotting and calculating is required on hydrofoil ships to avoid incidents and collisions which could ruin your whole day. It is important to keep radar surveillance coordinated with lookouts watching forward when at foilborne speeds.

Communications

Military units are in contact with each other and higher authority at all times. Communication is selected on the basis of the requirements in effect at the time. For example, radio links in plain language are used bridge to bridge between warships and freighters, tankers, fishermen, or yachts. Orders, or other warship information is scrambled. In addition, running lights and light signals are standard for international or inland waters according to the rules of the road. Flashing signal lights in Morse code may be sailor talk between signalmen or official communications.

Flag signal communication, frequently called wig-wag or semaphore, is another communication which is official, and allows sailors to communicate between ships, or even between portholes. Flag signal hoists have been used for centuries, and still serve the same purpose.

Telephone lines are the first to be connected ashore when making port and the last to be disconnected when getting underway. Telephones, intercoms, and announcing systems are standard throughout warships.

Damage Control

Compartmentation provides protection from fire or flooding and a means of containing damage to permit damage control parties to put out a fire or repair a hole in the hull. Damage control parties are trained to take action as the situation requires, even if the ship is still engaged in combat. Dewatering each compartment is effected by pumps with waterproof motors. Auxiliary hand held pumps assist or replace compartment pumps. Shoring to hold bulkheads or plug holes in the hull can be placed in position by the damage control party.

Ship Handling

Hullborne the *FHM* is a twin water-jet which handles like a twin screw vessel. It is assisted by a bow thruster and can be maneuvered laterally into a tight berth. *Sparviero* has a single water jet. Foilborne ship handling is similar to standard ship handling, with conning orders to a helmsman. It can also be handled like a speed boat, with the Captain on the helm driving it like a sports car. Close encounters at high speed call for excellent coordination between the Conning Officer and the Helmsman.

Ship Operation Planning
Speed, Time, and Distance are related by the equation 60D=ST where Distance is in nautical miles Speed is in knots, and Time is in minutes Time is also measured by fuel burned when foilborne, or hullborne Weather and Sea are not significant operational factors unless the wind and sea become very stormy with very high seas Tides and drafts are of concern entering and leaving the harbor or crossing river bars Foilborne and foils down operation requires water depth sufficient to land and navigate on the hull with the draft of foils extended, foils up only requires keel clearance unless the bottom will damage the waterjets

Takeoff and landing require sufficient space to get foilborne, either straight-a way like an airplane or in a turn The time to take off in a turn is increased, but the time to land in a turn is decreased Sufficient sea room is necessary in either case.

Sea Water Cooling
The sea water even in the tropics keeps the machinery and equipment from overheating and malfunctioning It is bled out of the propulsion systems and fed through heat exchangers in the ship It cools the gun barrel during firing allowing continuous rapid firing

Ship Maintenance Cycles
On board maintenance is accomplished by the crew, while periodic maintenance is done by the Mobile Logistic Support Group Trouble shooting in port is effected by both Maintenance is cycled to keep the ship operational and ready at all times Inspections are performed on a scheduled basis and whenever any indication of unusual performance is noted Squawks of "equipment out" are red tagged Each is then considered individually and on the basis of the operational requirements for the next mission

Military Equipment
Naval Rifle, 76 mm Oto Melara rapid fire water-cooled cannon mounted on the forward deck
Harpoon Missiles canister loaded mounted on launchers at the transom aimed port and starboard over the shoulder
RBOC Chaff, mortar loaded, mounted on the top of the deck house aft of the pilot house and mast.
Fire Control System, Mk 92 Gun fire control system, and the surface-to-surface missile fire control system mounted in the deck house Combat Information Center
Ammunition, small arms and pyrotechnics are stored in a locked magazine for use in hand-to-hand combat and crew security

Emergency Procedures
Casualty control an ounce of prevention is worth a pound of cure, applies to almost every situation Cross training of members of the crew in trouble shooting, fighting fires, repairing battle damage, and controlling flooding is essential in small size high speed combatants

Collision with friendly vessels can be avoided by close watch ahead, radar warning and rapid plotting of the course and speed of vessels forward of the beam. The exceptional turning speed and small radius enable hydrofoils to dodge around obstacles other ships may not be able to avoid hitting.

Intentional collision with enemy vessels and the use of the stainless steel foils as can openers along the sides of thin steel ships is a last ditch command decision, with high risk of loss of the hydrofoil.

NOTICE

ELECTRONIC ARTS RESERVES THE RIGHT TO MAKE IMPROVEMENTS IN THE PRODUCT DESCRIBED IN THIS MANUAL AT ANY TIME AND WITHOUT NOTICE

THIS MANUAL IS COPYRIGHTED. ALL RIGHTS ARE RESERVED. NO PART OF THIS MANUAL OR ANY OF THE ACCOMPANYING MATERIALS MAY BE COPIED, REPRODUCED, TRANSLATED OR REDUCED TO ANY ELECTRONIC MEDIUM OR MACHINE READABLE FORM WITHOUT THE PRIOR WRITTEN CONSENT OF ELECTRONIC ARTS, 1820 GATEWAY DRIVE, SAN MATEO, CALIFORNIA 94404

ELECTRONIC ARTS MAKES CERTAIN LIMITED WARRANTIES WITH REGARD TO DEFECTIVE RECORDING MEDIA. PLEASE SEE THE ELECTRONIC ARTS LIMITED WARRANTY ENCLOSED WITH THIS PRODUCT.

MANUAL BY NICHOLAS LAVROFF & LUCASFILM GAMES DIVISION

© 1986 ELECTRONIC ARTS

PHM Pegasus was created by the Lucasfilm Games Division. Noah Falstein was the designer and head programmer. Larry Holland and Edwin Reich were programmers on the Apple II and Commodore 64 versions. Ken Macklin did the artwork. Chris Grigg designed the sounds and music. Charlie Kellner, Ron Gilbert and Randy Farmer contributed algorithms and special program routines. Steve Arnold, Mary Paterno and Nancy Mohler provided logistical and administrative support. Other members of the division helped with testing and suggestions.

Special thanks to George Lucas

™ & © Lucasfilm Ltd. All rights reserved. PHM Pegasus and Lucasfilm Games are trademarks of Lucasfilm Ltd. All rights reserved. Electronic Arts, Authorized User

ELECTRONIC ARTS™

1820 Gateway Drive, San Mateo, Ca 94404

125105